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Surveillance Air Monitoring

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Introduction

Air surveillance monitoring is performed to evaluate compliance with local, state, and federal laws and regulations and to ensure that human health and the environment are protected from hazardous and radioactive air emissions. Federal environmental air quality laws and Department of Energy (DOE) regulations include 40 Code of Federal Regulations (CFR) 61, the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) section of the Clean Air Act, and DOE Orders 5400.1, *General Environmental Protection Program*, and 5400.5, *Radiation Protection of the Public and the Environment*. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991) provides the guidance for implementing DOE Orders 5400.1 and 5400.5. The California Air Toxics "Hot Spots" Information and Assessment Act of 1987 (AB2588) also governs air quality. In general, the constituents that LLNL analyzes are at levels far below the regulatory standards.

LLNL conducts surveillance monitoring of ambient air to determine if airborne radionuclides or hazardous materials are being released by Laboratory operations, what the concentrations are, and what the trends are in the LLNL environs. In the air monitoring program, LLNL collects particles on filters and chemically traps vapors on a collection medium. Concentrations of various airborne radionuclides (including particles and tritiated water vapor) and beryllium are measured at the Livermore site, Site 300, and at off-site locations throughout the Livermore Valley and in Tracy. In addition, some point sources and diffuse, or nonpoint sources, are monitored to fulfill NESHAPs requirements (Gallegos et al. 1998).

Methods

Several monitoring networks are established for surveillance of air particulates in the environs of LLNL and Site 300, as well as in the surrounding Livermore Valley and in Tracy. The sampling locations for each monitoring network are listed in **Table 5-1** and shown on **Figures 5-1**, **5-2**, and **5-3**. All monitoring networks use continuously

operating samplers. The radiological high-volume sampling networks use glass fiber filters, the beryllium high-volume networks use cellulose filters, and the low volume network uses Millipore AW-19 filters.

Table 5-1. Sampling locations listed by monitoring network.

High-volume radiological (glass fiber filters)	High-volume beryllium (cellulose filters)	Low-volume gross alpha and beta (millipore filters)	Tritium (silica gel)
Livermore site locations			
SALV CAFE VIS COW MET MESQ B531[a] CRED[a]	SALV CAFE VIS COW MET MESQ		SALV CAFE VIS COW MET MESQ POOL B292[a] B331[a] B514[a] B624[a]
Livermore Valley locations			
FCC FIRE HOSP CHUR PATT ZON7 TANK AMON[b] LWRP		FCC HOSP	FIRE XRDS ZON7 VET HOSP AMON[b]
Site 300			
801E ECP EOBS GOLF NPS WCP WOBS	EOBS GOLF 801E		
Site 300 off site			
TFIR PRIM	TFIR		PRIM

[a] These locations are in areas of diffuse sources and are monitored to fulfill NESHAPs requirements.

[b] Location AMON replaced location ALTA which was removed from service in April 1997.

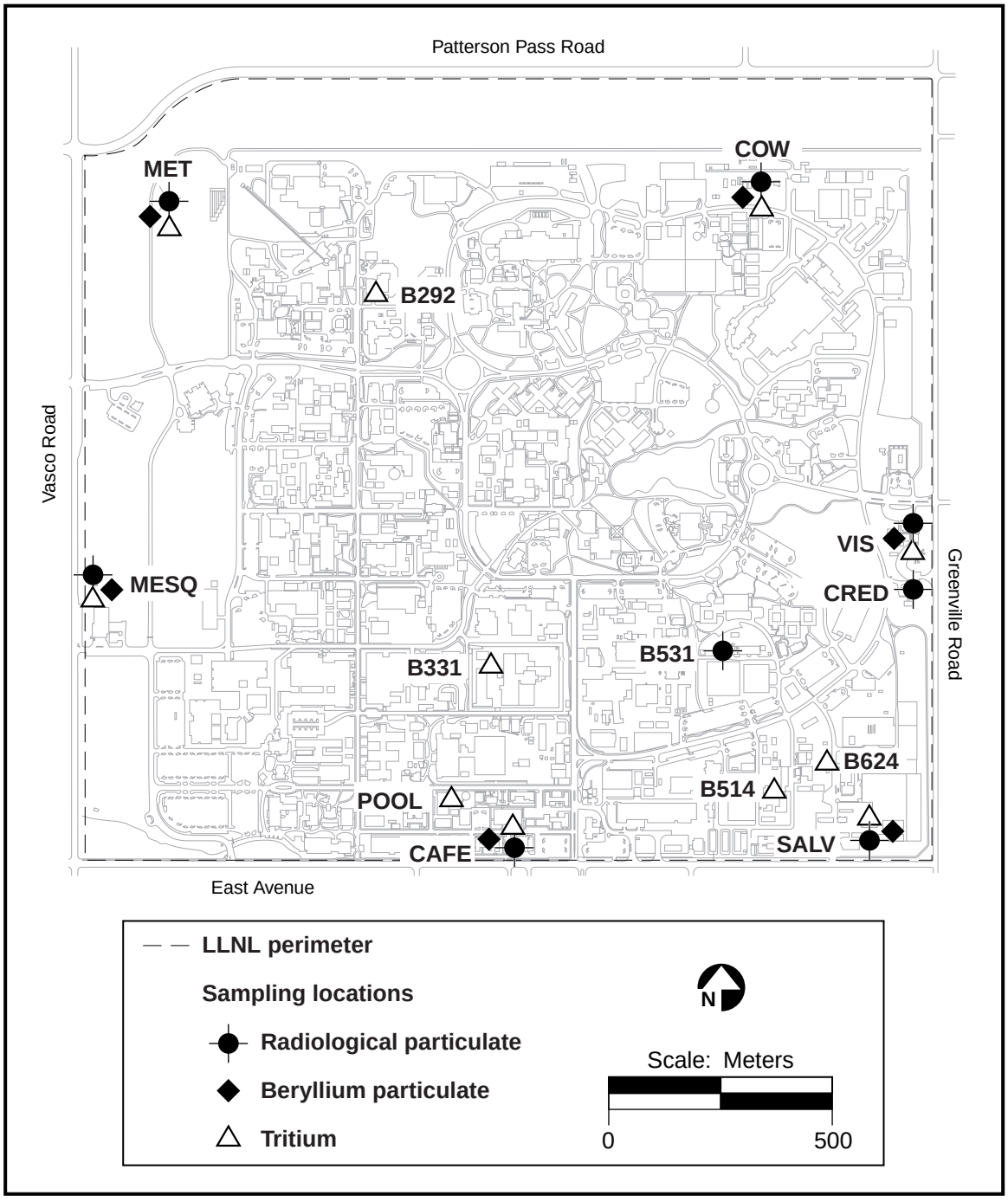

Figure 5-1. Air particulate and tritium sampling locations on the Livermore site, 1998.

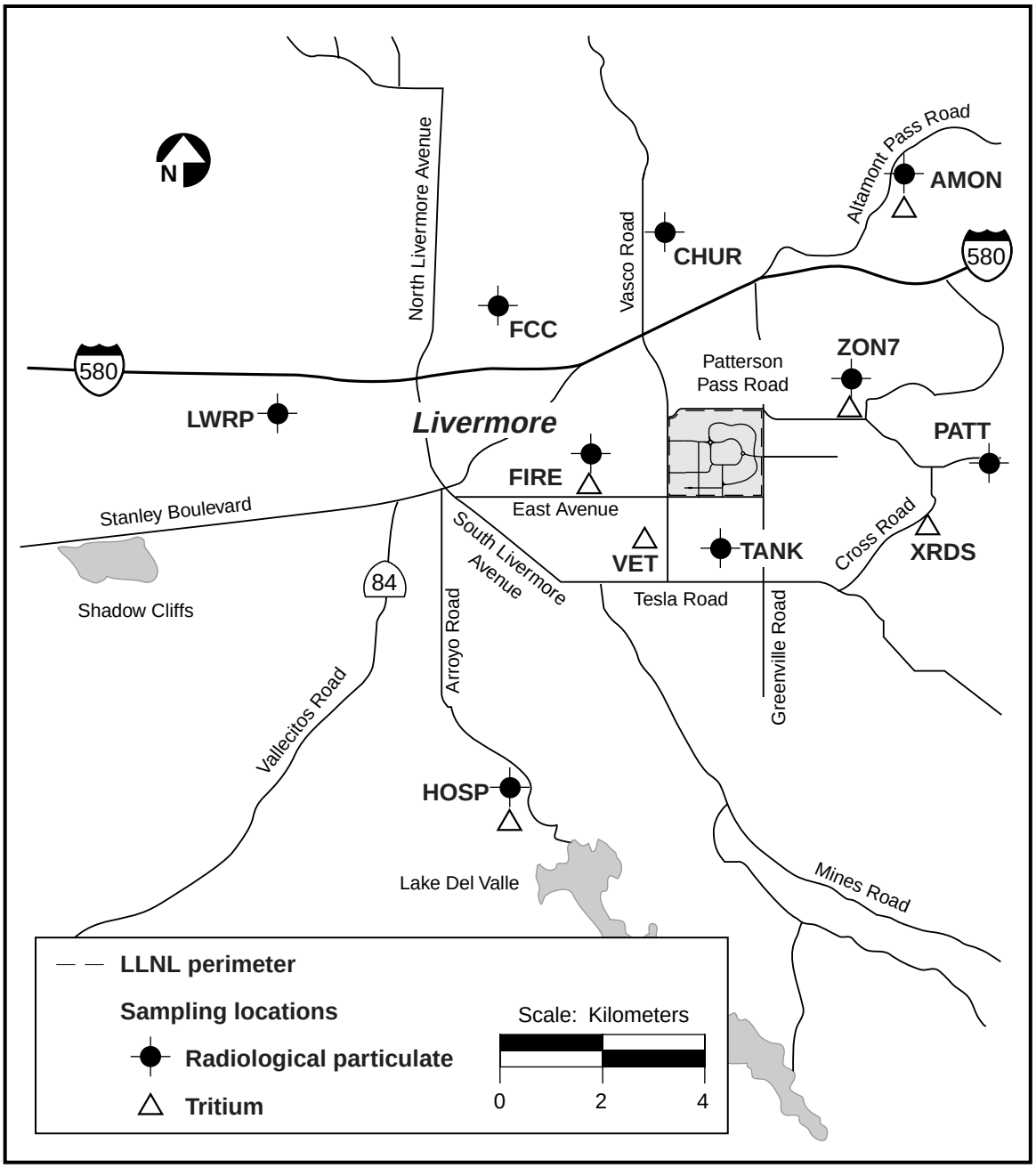

Figure 5-2. Air particulate and tritium sampling locations in the Livermore Valley, 1998.

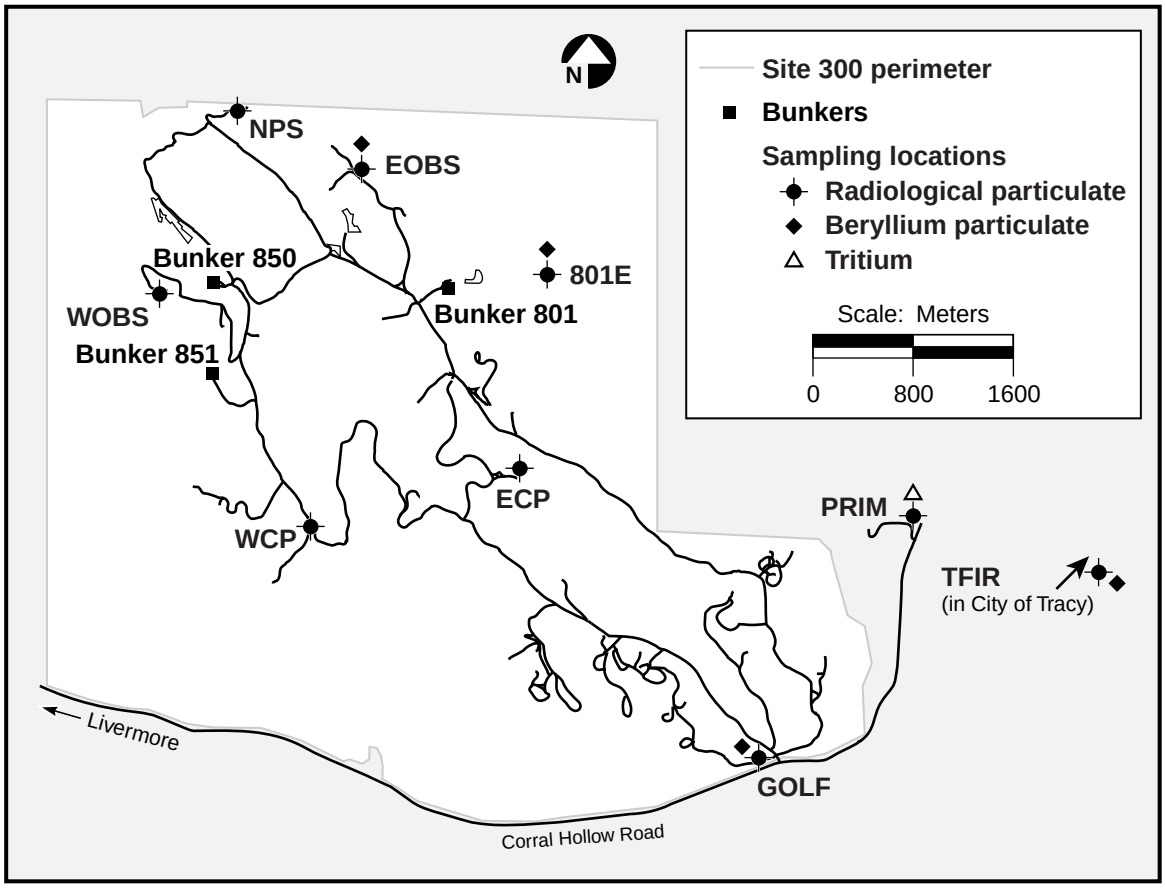

Figure 5-3. Air particulate and tritium sampling locations at Site 300, 1998.

The Livermore site radiological air particulate network consists of six samplers at the perimeter. In addition, two areas of special interest (B531 and CRED) are monitored for plutonium only. These two locations are areas of known plutonium contamination in the southeast quadrant attributed to historic operations, which included the operation of solar evaporators for plutonium-containing liquid waste. The Livermore Valley network consists of air samplers located in all compass directions. For the purposes of data analysis, four samplers located in the least prevalent wind directions (FCC, FIRE, HOSP, and CHUR) are considered to be upwind or representative of background locations, and four samplers located in the most prevalent downwind directions (PATT, ZON7, TANK, and AMON) are considered most likely to be affected by Laboratory operations. An additional sampler is located in another area of special interest, the Livermore Water Reclamation Plant (LWRP), because of a plutonium release to the sanitary sewer system in 1967 with subsequent soil contamination and potential resuspension (see Results section below).

Livermore site beryllium monitoring continues at the six perimeter locations. To satisfy beryllium reporting requirements and determine the effects of the Laboratory's beryllium operations, in 1997, LLNL conducted a technical assessment of the beryllium monitoring locations at Site 300. There is no requirement to sample for beryllium at Site 300; however, as a best management practice, LLNL has decided to continue beryllium monitoring at three locations on site and at TFIR in the City of Tracy.

All air samplers are positioned to provide reasonable probability that, if there is any significant concentration of radioactive particulate or beryllium effluents from LLNL operations, it will be detected. The geographical details of the particulate sampling locations are outlined in a procedure in Appendix B of the *Environmental Monitoring Plan* (Tate et al. 1995).

Two sampling systems were added in July 1997 as part of the new low-volume air surveillance sampling network. The samplers are situated at the FCC and HOSP locations, sites that are generally upwind of the Livermore site. The results are used to establish background levels of gross alpha and beta activity for direct comparison to results from the air effluent samplers (see Chapter 4). The sampling systems are very similar to the air effluent samplers used in facilities, including sampling system design, sampler operation, filter media, sample tracking, sample analysis, and processing of results.

LLNL also maintains 11 continuously operating airborne tritium samplers on the Livermore site (**Figure 5-1**), six samplers in the Livermore Valley (**Figure 5-2**), and one sampler near Site 300 (**Figure 5-3**) to assess historical and current activities that influence environmental impacts. Four of the Livermore site locations (B331, B292, B514, and B624) monitor diffuse tritium emissions. The tritium sample locations are detailed in Appendix B of the *Environmental Monitoring Plan* (Tate et al. 1995).

Particulate filters are changed each week at all locations, and tritium samples are changed every two weeks. Duplicate quality control samplers are operated for two months in parallel with the permanent sampler at a given site, and samples are analyzed to confirm results.

As outlined in *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991), gross alpha and gross beta air filter results are used as trend indicators; specific radionuclide analysis is done for plutonium, uranium, and gamma emitters. Radiological analytical results are reported as a measured concentration per volume of air, or as less than the minimum detection concentration (MDC) when no activity is detected. In all cases, the MDC is more than adequate for demonstrating compliance with the pertinent regulatory requirements

for radionuclides that may be or are present in the air sample and for evaluating LLNL-induced environmental impacts. Particle size distributions are not determined because the estimated effective dose equivalent to the maximally exposed individual is well below the 0.01-mSv (1-mrem) allowable limit as discussed in the above-mentioned *Environmental Regulatory Guide.* Gross alpha and gross beta activities are determined by gas-flow proportional counting, plutonium by alpha spectrometry, uranium by mass spectrometry, and gamma by gamma spectroscopy. Further details of the surveillance monitoring methods are included in the Data Supplement, Chapter 5.

Results

This section discusses the air monitoring results from all air surveillance locations at the Livermore site, Site 300, and all off-site surveillance locations.

In April 1997, the air particulate sampling filter media was changed from cellulose to glass fiber; however, blank glass-fiber filters contain detectable amounts of some naturally occurring radiological isotopes (Althouse 1998) including ^{235}U, ^{238}U, ^{40}K, ^{226}Ra, ^{228}Ra, and ^{228}Th. LLNL adjusted the measured concentrations of these isotopes according to U.S. Environmental Protection Agency (EPA) procedures (Eadie and Bernhardt 1976) and subtracted the appropriate blank filter content from the gross analytical result to obtain a corrected net result.

Livermore Site

Airborne Radioactivity

Table 5-2 summarizes the monthly gross alpha and gross beta results for the LLNL perimeter, Livermore Valley, and Site 300 sampling locations. Detection frequencies, median concentrations, interquartile ranges (IQR), and maximum concentrations values for each network are included. (See Data Supplement, Tables 5-1, 5-2, and 5-3 for detailed location results for all high-volume networks for gross alpha and gross beta concentrations.) The monthly median gross alpha and gross beta concentrations are plotted in **Figures 5-4** and **5-5**, respectively. The gross beta results follow a similar pattern to previous years' data. The gradual increase in beta activity throughout the summer is most likely due to an increase in resuspension of soils that occurs during the dry season.

Table 5-2. Gross alpha and gross beta concentration in air particulate samples summarized by month, 1998.[a]

Month	Gross alpha (10^{-6} Bq/m^3)				Gross beta (10^{-6} Bq/m^3)			
	Detection frequency[b]	Median	IQR[c]	Maximum	Detection frequency	Median	IQR	Maximum
LLNL perimeter								
Jan	5/30	26.8	39.3	141	30/30	247	197	902
Feb	0/24	–5.84	18.5	28.4	17/24	142	66.1	273
Mar	0/24	–1.83	34.2	36.5	24/24	283	167	634
Apr	0/24	–2.54	26.3	35.0	23/24	251	130	599
May	1/30	–2.47	34.5	73.9	30/30	174	58.5	531
Jun	8/24	32.3	40.5	78.2	19/24	180	78.8	373
Jul	9/30	26.6	49.8	110	30/30	378	120	555
Aug	8/24	34.5	30.8	74.7	24/24	606	154	849
Sep	0/24	13.1	53.4	57.5	24/24	484	269	980
Oct	2/30	6.22	36.0	68.3	30/30	488	222	805
Nov	1/24	10.5	41.3	78.2	23/24	304	258	648
Dec	4/24	23.9	30.3	90.8	24/24	617	564	1520
Livermore Valley upwind								
Jan	3/20	31.4	33.0	66.5	20/20	244	235	972
Feb	0/16	1.44	10.2	33.4	16/16	133	60.8	243
Mar	1/16	2.03	28.3	63.0	16/16	298	193	533
Apr	0/16	–7.07	23.4	28.6	15/16	219	152	540
May	1/20	6.49	25.7	62.9	19/20	131	111	470
Jun	2/16	25.6	31.9	59.0	13/16	163	95.7	304
Jul	2/20	21.2	22.5	80.2	20/20	371	102	657
Aug	1/16	20.2	33.2	55.5	16/16	639	174	832
Sep	0/16	9.44	41.5	55.5	16/16	495	281	1050
Oct	0/20	9.69	36.6	46.9	20/20	438	191	911
Nov	1/16	9.57	31.4	61.9	15/16	234	304	564
Dec	1/16	11.9	14.8	78.0	16/16	621	470	1620

Table 5-2. Gross alpha and gross beta concentration in air particulate samples summarized by month, 1998 (concluded).[a]

Month	Gross alpha (10^{-6} Bq/m^3)				Gross beta (10^{-6} Bq/m^3)			
	Detection frequency[b]	Median	IQR[c]	Maximum	Detection frequency	Median	IQR	Maximum
Livermore Valley downwind								
Jan	0/20	16.4	42.7	46.5	19/20	232	244	936
Feb	0/16	–9.38	12.0	22.4	14/16	141	40.9	205
Mar	2/15	19.3	30.9	67.0	15/15	288	127	648
Apr	0/16	–5.71	34.6	32.9	14/16	248	150	684
May	0/20	–8.57	28.0	48.4	19/20	175	71.0	500
Jun	3/16	18.0	28.8	119	16/16	192	64.0	388
Jul	1/19	15.9	29.6	76.1	19/19	445	94.9	712
Aug	5/16	27.4	46.3	118	16/16	648	125	813
Sep	1/16	16.3	34.8	113	16/16	531	153	1050
Oct	2/20	0.924	26.0	92.0	20/20	450	207	858
Nov	0/15	10.2	18.7	54.2	15/15	283	304	685
Dec	2/16	6.86	39.4	55.7	16/16	645	922	1440
Site 300[d]								
Jan	8/35	24.4	46.8	81.6	33/35	229	223	634
Feb	1/28	–3.55	32.1	64.3	23/28	112	64.3	237
Mar	0/28	5.90	25.9	65.3	27/28	284	208	584
Apr	2/27	6.57	41.5	61.0	25/27	376	335	667
May	3/33	–2.04	35.0	86.3	27/33	154	120	381
Jun	1/28	10.3	34.0	53.1	28/28	217	44.0	297
Jul	7/34	30.7	27.8	104	34/34	516	124	784
Aug	14/28	43.9	56.4	108	28/28	653	194	1080
Sep	5/28	19.5	59.9	154	28/28	598	538	1180
Oct	1/35	3.96	32.2	73.9	35/35	534	304	927
Nov	1/28	14.9	42.7	56.2	28/28	294	333	771
Dec	1/27	23.2	37.3	65.9	25/27	685	566	1680

a Negative values occur when the activity of the analytical background filters is greater than that of the filters being analyzed.

b Detection frequency is the number of samples with results above the detection limit divided by the number of samples.

c IQR = Interquartile range.

d Results for location TFIR and PRIM are given in the Data Supplement, Table 5-15.

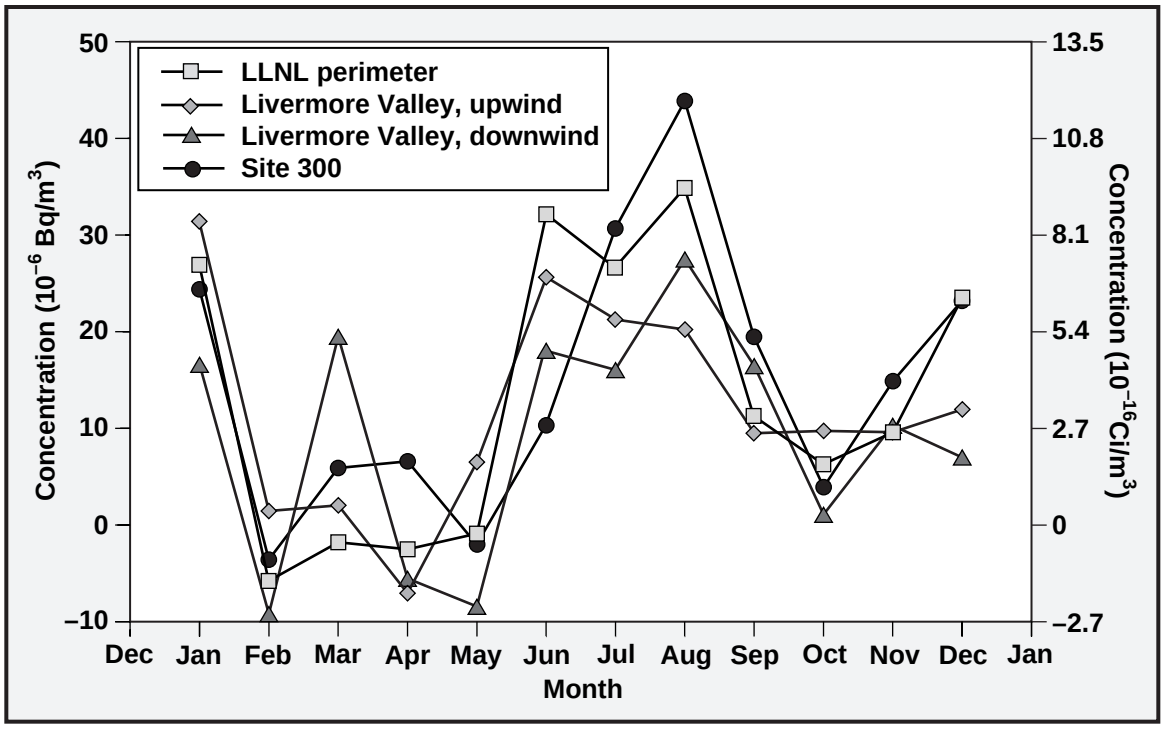

Figure 5-4. Monthly median gross alpha concentrations in particulate air samples from the LLNL perimeter, Livermore Valley and Site 300 sampling locations, 1998.

The gross alpha data are much more variable because of the standard analytical method capabilities, and most of the data are very close to the minimum detection limit of the method.

Typical gross alpha activity (median value) for the LLNL perimeter is 1.2×10^{-5} Bq / m^3 (3.2×10^{-16} Ci / m^3); for the upwind Livermore Valley stations, the value is 6.9×10^{-6} Bq / m^3 (1.9×10^{-16} Ci / m^3); and for the downwind Livermore Valley stations the value is 2.1×10^{-5} Bq / m^3 (5.7×10^{-16} Ci / m^3). Negative values occur when the activity of the analytical background filters is higher than the activity on the filters being analyzed. Typical gross beta activity (median value) for the LLNL perimeter is 3.3×10^{-4} Bq / m^3 (8.9×10^{-15} Ci / m^3); for the upwind Livermore Valley stations, the value is 3.0×10^{-4} Bq / m^3 (8.1×10^{-15} Ci / m^3); and for the downwind Livermore stations, the value is 3.4×10^{-4} Bq / m^3 (9.2×10^{-15} Ci / m^3). These values are similar to those obtained from previous monitoring data during the past several years. The primary sources of the alpha and beta activities are the naturally occurring radioisotopes of uranium and thorium, and any residual fallout from atmospheric weapons testing and the Chernobyl reactor accident in 1986.

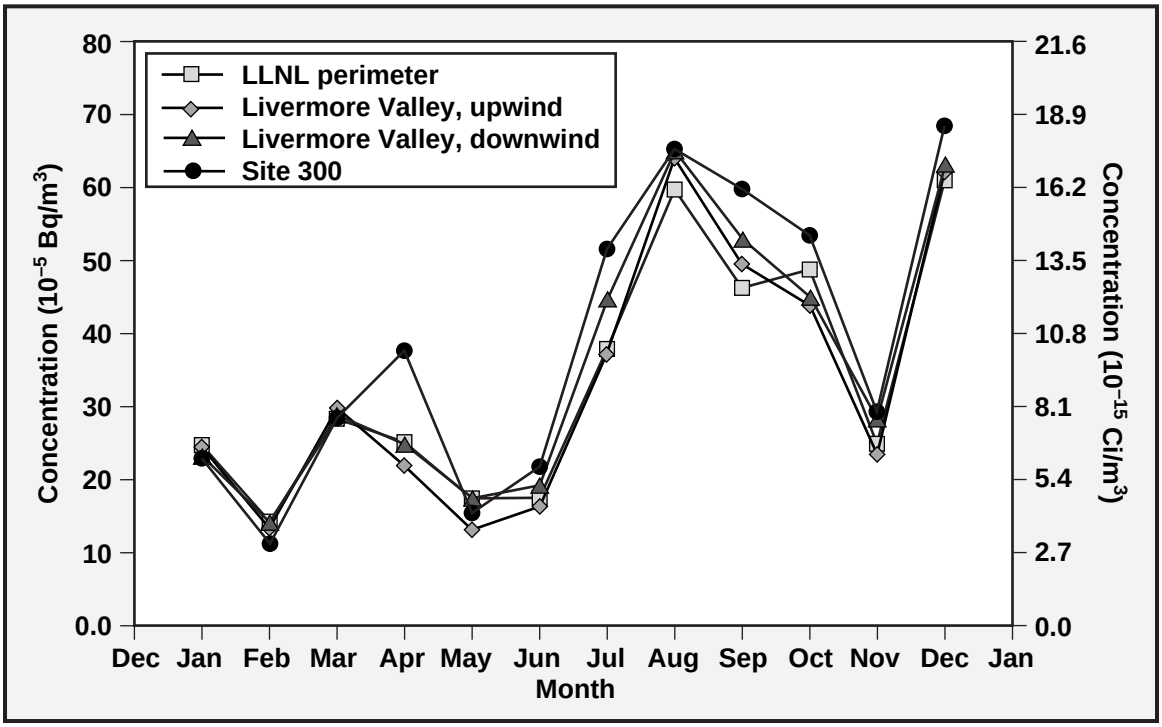

Figure 5-5. Monthly median gross beta concentrations in particulate air samples from the LLNL perimeter, Livermore Valley, and Site 300 sampling locations, 1998.

Gamma-emitting radionuclide concentrations in air that contribute to the activity in the Livermore site perimeter samples are summarized in **Table 5-3**. (See Data Supplement, Table 5-4 for monthly gamma activity data.) Of the nuclides tabulated, ^{7}Be, ^{40}K, ^{226}Ra, ^{228}Ra, and ^{228}Th occur naturally. The primary source of ^{137}Cs is long-term global fallout and fallout resuspension.

By analyzing these radionuclides, LLNL can monitor the containment of the small inventories of mixed fission products and radiochemical tracers used at LLNL as well as obtain baseline data on global fallout. The Derived Concentration Guides (DCGs) for these radionuclides are shown in **Table 5-3**. For air, DCGs specify the concentrations of radionuclides that could be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public, which is 1 mSv/y (100 mrem/y) effective dose equivalent (DOE Order 5400.5). (Chapter 13, Radiological Dose Assessment, provides an explanation of this and other units of dose.) **Table 5-3** also presents the median fraction of the DCGs, which demonstrates that the level of gamma activity present in air at the Livermore site perimeter is far below the DCGs.

Table 5-3. Gamma activity in air particulate samples, Livermore site perimeter and Site 300, 1998.

	^{7}Be	^{40}K	^{137}Cs	^{22}Na	^{226}Ra	^{228}Ra	^{228}Th
	(10^{-3} Bq/m^3)	(10^{-6} Bq/m^3)					
Livermore perimeter							
Median	3.4	14	<0.22	<0.25	0.03	0.76	0.88
Interquartile range	1.4	18	—[a]	—[a]	3.7	1.0	1.0
Maximum	4.4	51	<0.28	<0.35	1.2	1.8	1.9
Median fraction of DCG[b]	2.3×10^{-6}	4.3×10^{-7}	$<1.5 \times 10^{-8}$	$<6.9 \times 10^{-9}$	3.1×10^{-5}	6.9×10^{-6}	5.8×10^{-4}
Site 300							
Median	3.4	26	<0.21	<0.25	–0.04	0.64	1.0
Interquartile range	2.2	55	—[a]	—[a]	3.8	1.5	2.4
Maximum	6.5	53	0.46	0.86	1.6	1.9	2.5
Median fraction of DCG	1.5×10^{-6}	7.7×10^{-7}	$<1.4 \times 10^{-8}$	$<6.8 \times 10^{-9}$	4.3×10^{-5}[c]	5.8×10^{-6}	6.9×10^{-4}
DCG (Bq/m^3)	1.5×10^{3}	3.3×10^{1}	1.5×10^{1}	3.7×10^{1}	3.7×10^{-2}	1.1×10^{-1}	1.5×10^{-3}

Note: Radioactivities are reported as the measured concentration and either an uncertainty (±2σ counting error) or as being less than or equal to the detection limit. If the concentration is less than or equal to the uncertainty or the detection limit, the result is considered to be a nondetection. See the main volume, Chapter 14, Quality Assurance.

a No measure of dispersion calculated. See Chapter 14, Quality Assurance.

b Derived Concentration Guide.

c Fraction of DCG calculated with maximum value since the median is negative.

Table 5-4 shows the concentrations of airborne $^{239+240}$Pu on air filters from the LLNL perimeter locations. (See Data Supplement, Table 5-6, for the monthly data by location.) The highest concentration was registered at location VIS in June 1998; the concentration value is reported as 4.4×10^{-8} Bq / m^3 (1.2×10^{-18} Ci / m^3), which represents 0.01% of the DCG. The median concentration at location VIS is 8.6×10^{-9} Bq / m^3 (2.3×10^{-19} Ci / m^3), which is slightly higher than that for the previous year.

Table 5-4 also shows the detection frequency, median concentration, IQR, maximum concentration, and median fraction of DCG for the concentration of plutonium on air filter samples collected in the Livermore Valley. (See Data Supplement, Table 5-5 for monthly data.) The highest off-site median concentration of $^{239+240}$Pu occurred at ZON7. Soils near ZON7 contain some detectable plutonium, principally resulting from historic operations of solar evaporators for plutonium-containing liquid waste in the southeast quadrant (Silver et al. 1974) (see Chapter 10, Soil and Sediment Monitoring). Resuspension of these soils probably accounts for the slightly higher median $^{239+240}$Pu in air concentrations; however, the median observed value is <0.001% of the DCG.

Table 5-4. Plutonium-239+240 activity in air particulate samples (10^{-9} Bq/m^3), 1998.

Sampling location[a]	Detection frequency[b]	Median	Interquartile range	Maximum	Median fraction of DCG[c]
Livermore Valley downwind locations					
AMON	2/10	1.8	4.5	19	2.5×10^{-6}
PATT	0/12	1.1	2.5	6.0[d]	1.6×10^{-6}
TANK	1/11	1.2	3.5	5.8	1.7×10^{-6}
ZON7	1/12	5.4	5.8	11	7.4×10^{-6}
Livermore Valley upwind locations					
FCC	0/12	1.6	2.0	7.0[d]	$2.2 \times 10–6$
FIRE	1/12	2.8	3.3	10	$3.8 \times 10–6$
HOSP	1/12	3.3	3.9	11	$4.4 \times 10–6$
CHUR	0/12	1.8	3.3	4.4[d]	$2.4 \times 10–6$
LLNL perimeter					
CAFE	1/12	5.9	2.7	16	8.0×10^{-6}
COW	2/12	2.4	4.6	10	3.2×10^{-6}
MESQ	1/12	2.3	4.2	9.0	3.1×10^{-6}
MET	1/12	1.4	2.5	7.6	1.9×10^{-6}
SALV	1/12	4.4	3.7	5.6	5.9×10^{-6}
VIS	8/12	8.6	7.2	44	1.2×10^{-5}
Diffuse on-site sources					
B531	10/12	16	51	110	2.1×10^{-5}
CRED	1/12	1.2	3.3	9.9	1.6×10^{-6}
Special interest					
LWRP	5/12	4.5	12	25	6.0×10^{-6}
Site 300 on-site					
S300 composite	3/12	1.6	1.4	16	2.1×10^{-6}
Site 300 off-site					
PRIM	2/12	2.2	3.4	11	2.9×10^{-6}
TFIR	1/12	0.86	5.2	11	1.2×10^{-6}

a See **Figures 5-1**, **5-2**, and **5-3** for sampling locations.

b Detection frequency is the number of samples with results above the detection limit divided by the number of samples.

c DCG = Derived Concentration Guide of 7.4 x 10^{-4} Bq/m^3 (2 x 10^{-8} µCi/m^3) for ^{239}Pu activity in air.

d Maximum value shown is less than the reported error and considered a nondetect.

Table 5-4 shows the median concentrations of airborne $^{239+240}Pu$ at the two diffuse source locations (B531 and CRED). (See Data Supplement, Table 5-7 for monthly data.) The median concentration of 1.6×10^{-8} Bq / m^3 (4.3×10^{-19} Ci / m^3) at location B531 is higher than the median concentration for any of the other air particulate sampling locations, but it is still only 0.01% of the DCG. The higher concentrations are attributed to historic waste management operations, which included the operation of solar evaporators for plutonium-containing liquid waste (Silver et al. 1974).

Figure 5-6 shows the annual median concentrations of $^{239+240}Pu$ for locations SALV (on site) and FCC (off site) from 1982 to 1998. Location FCC represents a typical upwind background location, and SALV represents a typical perimeter location. The annual median concentration for FCC was 1.6×10^{-9} Bq / m^3 (4.3×10^{-20} Ci / m^3). **Figure 5-6** uses a log scale; for the years in which a negative median concentration was calculated, the positive value closest to the median is plotted. The higher values in the past at SALV may be attributed to historical activities at LLNL; operational processes in the immediate work area have contributed to the observed downward trend of the data. The downward trend at location FCC is the result of decreasing global fallout.

The median ^{235}U and ^{238}U mass concentrations in air samples from the Livermore site perimeter are shown in **Table 5-5**. (See Data Supplement, Table 5-8, for monthly data.) The maximum measured concentration of ^{238}U (at location VIS during September) is less than 0.07% of the DCG. All $^{235}U / ^{238}U$ median ratios are as expected for naturally occurring uranium; however, monthly data in the Data Supplement show some unexpected $^{235}U / ^{238}U$ ratios. These ratios are most likely caused by the change to more efficient filter media that contain sufficient levels of uranium to interfere with the measurements. No significant environmental impact stems from the observed ratios.

Typical gross alpha and gross beta activity from the low-volume sampling locations HOSP and FCC is 5.4×10^{-11} Bq / mL (1.5×10^{-21} Ci / mL) and 5.0×10^{-10} Bq / mL (1.4×10^{-20} Ci / mL), respectively. (See Data Supplement, Tables 5-9 and 5-10, for monthly median data.) These gross alpha values are higher than those reported from the high-volume sampling systems at the same locations. The difference is probably due to differences in the filter type, and LLNL is conducting a study to determine the cause of the differences.

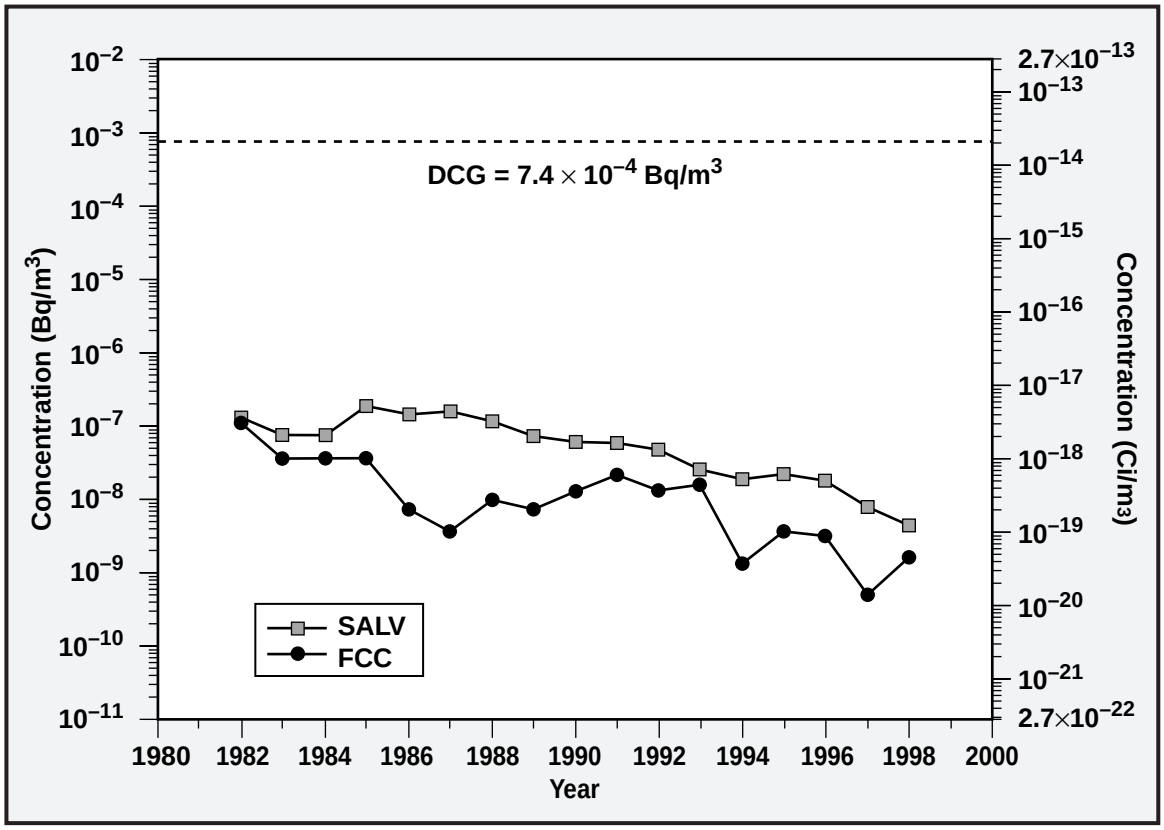

Figure 5-6. Median plutonium concentrations in air particulate samples at two locations, SALV and FCC, 1982 to 1998 (DCG = 7.4×10^{-4} Bq/m^3).

Table 5-6 shows the median concentrations of tritiated water vapor for the Livermore Valley sampling locations. (See Data Supplement, Table 5-11, for biweekly data for each location.) The highest annual median concentration was observed at location ZON7. At approximately 2.5×10^{-2} Bq / m^3 (6.6×10^{-13} Ci / m^3), this concentration represents 0.0007% of the DCG. The highest biweekly concentration was observed in January at ZON7. If it were a yearly average, this concentration, 7.3×10^{-2} Bq / m^3 (2.0×10^{-12} Ci / m^3), would be 0.002% of the DCG. The 1998 tritium values are generally similar to those reported last year.

Table 5-6 also shows the median concentrations of tritiated water vapor that were observed at the Livermore site perimeter sampling locations. (See Data Supplement, Table 5-12, for biweekly data.) The highest annual median concentration was observed at location POOL, which was 0.18 Bq / m^3 (4.9×10^{-12} Ci / m^3), or 0.005% of the DCG.

Table 5-5. Uranium mass concentration in air particulate samples, 1998.

Sampling location[a]	^{238}U[b] (10^{-5} μg/m^3)	^{235}U[c] (10^{-7} μg/m^3)	$^{235}U/^{238}U$[d] (10^{-3})
CAFE			
Median	3.35	1.90	6.05
Interquartile range	3.81	2.75	2.25
Maximum	13.8	9.99	NA[e]
Median fraction of DCG[f]	1.12×10^{-4}	4.04×10^{-6}	NA
COW			
Median	2.80	1.44	6.12
Interquartile range	3.87	3.15	1.41
Maximum	14.0	10.1	NA
Median fraction of DCG	9.35×10^{-5}	3.07×10^{-6}	NA
MESQ			
Median	3.70	2.21	6.31
Interquartile range	4.72	3.43	0.926
Maximum	15.8	11.6	NA
Median fraction of DCG	1.23×10^{-4}	4.71×10^{-6}	NA
MET			
Median	2.76	1.33	6.25
Interquartile range	5.31	3.91	1.02
Maximum	13.9	9.93	NA
Median fraction of DCG	9.18×10^{-5}	2.83×10^{-6}	NA
SALV			
Median	2.21	1.00	5.67
Interquartile range	4.53	3.32	2.43
Maximum	11.5	8.11	NA
Median fraction of DCG	7.35×10^{-5}	2.12×10^{-6}	NA
VIS			
Median	3.56	2.16	6.25
Interquartile range	6.33	4.16	1.43
Maximum	19.7	13.9	NA
Median fraction of DCG	1.19×10^{-4}	4.61×10^{-6}	NA
Site 300 (composite)			
Median	3.18	1.48	5.19
Interquartile range	10.7	7.49	3.27
Maximum	58.1	14.6	NA
Median fraction of DCG	1.06×10^{-4}	3.15×10^{-6}	NA

Table 5-5. Uranium mass in concentration air particulate samples, 1998 (concluded).

Sampling location[a]	^{238}U[b] (10^{-5} μg/m^3)	^{235}U[c] (10^{-7} μg/m^3)	$^{235}U/^{238}U$[d] (10^{-3})
PRIM			
Median	3.96	1.63	5.76
Interquartile range	5.64	3.75	1.86
Maximum	16.5	11.8	NA[e]
Median fraction of DCG[f]	1.32×10^{-4}	3.47×10^{-6}	NA

a See **Figures 5-1** and **5-3** for sampling locations.

b Derived Concentration Guide = 0.3 μg/m^3 for ^{238}U activity in air. Uranium-238 activities in Bq/m^3 can be determined by dividing the weight in μg/m^3 by 80.3, and pCi m^3 can be determined by dividing by 2.97.

c Derived Concentration Guide = 0.047 μg/m^3 for ^{235}U activity in air. Uranium-235 activities in Bq/m^3 can be determined by dividing the weight in μg/m^3 by 12.5, and pCi m^3 can be determined by dividing by 0.463.

d Naturally occurring uranium has a $^{235}U/^{238}U$ ratio of 7.1×10^{-3}.

e NA = Not applicable.

f DCG = Derived Concentration Guide.

Diffuse sources of tritium on the Livermore site are monitored at air tritium sampling locations B331, B292, B514, and B624. **Table 5-6** shows the median concentrations of tritiated water vapor for these sampling locations. (See Data Supplement, Table 5-13, for biweekly data.) The highest median concentration was observed at location B331. This concentration was 16.6 Bq / m^3 (4.5×10^{-10} Ci / m^3) and represents 0.4% of the DCG. The highest biweekly tritium concentration, 62.2 Bq / m^3 (1.7×10^{-9} Ci / m^3), was observed in September at location B331. If it were a yearly average, this concentration would represent 2% of the DCG.

The B331 location is near the Tritium Facility (Building 331), where LLNL personnel have reduced operations in recent years and performed significant inventory reduction and cleanup activities. During this process, tritium-contaminated equipment slated for disposal is stored in a waste accumulation area before being sent to Hazardous Waste Management facilities. During 1998, outgassing from such waste processing released an estimated 2.2×10^{11} Bq (6 Ci) of tritium to the atmosphere outside of Building 331.

The B624 location is situated in the Building 612 yard, which is dedicated to hazardous waste, radioactive waste, and mixed-waste management activities. The yard has several areas where waste containers that are outgassing tritium are stored outdoors.

Table 5-6. Tritium in air samples (in 10^{-3} Bq/m^3), 1998.

Sampling location[a]	Detection frequency[b]	Median	IQR[c]	Maximum	Median fraction of DCG[d]	Median dose (mSv)[e]
Livermore Valley						
ZON7	22/26	24.5	18.8	72.5	6.6×10^{-6}	5.4×10^{-6}
AMON	14/21	16.0	19.4	58.1	4.3×10^{-6}	3.5×10^{-6}
XRDS	12/26	7.59	13.4	29.4	2.1×10^{-6}	1.7×10^{-6}
FIRE	10/26	8.92	17.1	34.0	2.4×10^{-6}	1.9×10^{-6}
VET	14/26	14.0	24.5	46.3	3.8×10^{-6}	3.0×10^{-6}
HOSP	6/25	1.76	16.7	45.5	4.8×10^{-7}	3.8×10^{-7}
Livermore perimeter						
SALV	22/22	55.1	35.8	117	1.5×10^{-5}	1.2×10^{-5}
MESQ	22/26	20.4	39.9	108	5.5×10^{-6}	4.4×10^{-6}
CAFE	25/25	90.3	92.1	437	2.4×10^{-5}	2.0×10^{-5}
MET	20/26	23.9	28.8	57.4	6.5×10^{-6}	5.2×10^{-6}
VIS	23/23	91.4	40.7	147	2.5×10^{-5}	2.0×10^{-5}
COW	25/25	50.7	44.0	124	1.4×10^{-5}	1.1×10^{-5}
POOL	25/25	180	155	648	4.9×10^{-5}	3.9×10^{-5}
Diffuse on-site sources						
B292	24/25	91.0	61.8	207	2.5×10^{-5}	2.0×10^{-5}
B331	24/24	16,600	24,900	62,200	4.5×10^{-3}	3.6×10^{-3}
B514	24/24	2,700	3,850	10,100	7.3×10^{-4}	5.9×10^{-4}
B624	25/25	4,770	1,480	10,500	1.3×10^{-3}	1.0×10^{-3}
Site 300 off site						
PRIM	4/23	2.43	6.89	41.1	6.6×10^{-7}	5.3×10^{-7}

a See **Figures 5-1**, **5-2**, and **5-3** for sample locations.

b Detection frequency is the number of samples with results above the detection limit divided by the number of samples..

c IQR = Interquartile range.

d DCG = Derived Concentration Guide of 3.7×10^3 Bq/m^3.

e 1 mSv = 100 mrem.

The B514 sampling location is in a hazardous waste management area where tritium-contaminated waste is treated, and the B292 location is near an underground retention tank that had previously leaked. The concentrations in air at the B514 sampling location are variable because of the changing concentrations of tritium in the waste stream. The 1998 median concentrations at B292 are similar to the median concentrations in 1997.

Beryllium in Air

The median concentrations of airborne beryllium for the Livermore site perimeter sampling locations are shown in **Table 5-7**. (See Data Supplement, Table 5-14, for monthly data.) The highest value of 20 pg/m^3 was found in the July composite at location MESQ and was most likely the result of construction activities west of LLNL that cause greater amounts of resuspended particulate. The median concentration for this location is 0.09% of the monthly ambient concentration limit (ACL) of 10,000 pg/m^3 established by the Bay Area Air Quality Management District (BAAQMD) and the EPA.

Table 5-7. Beryllium in air particulate samples (in pg/m^3), Livermore site perimeter, and Site 300, 1998.

Sampling location[a]	Detection frequency[b]	Median	Interquartile range	Maximum
Livermore perimeter				
SALV	11/12	4.3	5.6	9.4
MESQ	12/12	8.6	7.2	20
CAFE	12/12	7.4	7.6	12
MET	12/12	5.0	6.9	13
VIS	12/12	4.8	7.9	15
COW	12/12	6.3	6.8	14
Site 300				
EOBS	11/12	5.1	6.9	21
GOLF	11/12	4.4	4.9	13
801E	11/12	8.1	8.3	37
TFIR	12/12	6.9	7.2	18

[a] See **Figures 5-1** and **5-3** for sampling locations.

[b] Detection frequency is the number of samples with results above the detection limit divided by the number of samples.

Figure 5-7 is a plot of the median beryllium concentration at the Livermore site perimeter from 1974 through 1998. The decrease in median concentration in 1993 was the result of a change in the analytical laboratory that was used. The overall median concentration during this time period was calculated to be 0.2% of the ACL. Unless there is a change in LLNL's operations, the beryllium levels are expected to remain unchanged.

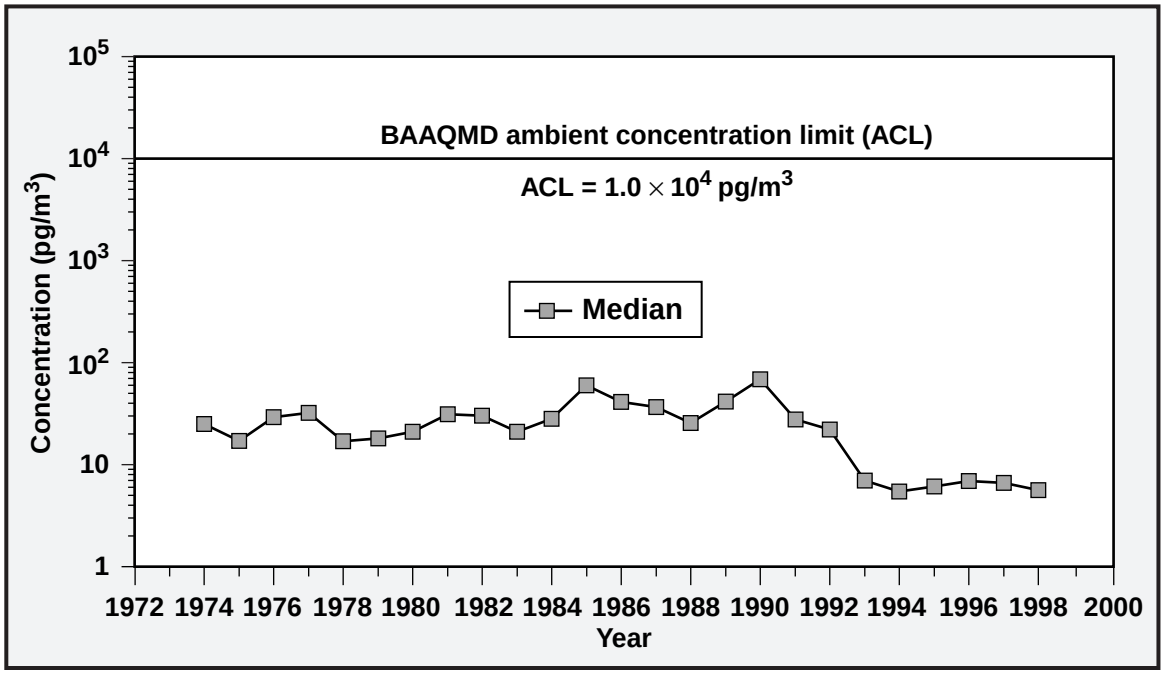

Figure 5-7. Median concentration of beryllium in air particulate samples taken at the Livermore site perimeter, 1974 to 1998.

Site 300

Airborne Radioactivity

Most gross alpha determinations at Site 300 were at or near the analytical limit of detection for the method and similar to those in previous years. **Table 5-2** shows the detection frequency and the monthly gross alpha and gross beta median, IQR, and maximum for sampling locations at Site 300. (See Data Supplement, Table 5-15 for monthly data.) The monthly median gross alpha and gross beta concentrations are shown in **Figures 5-4** and **5-5**. The Site 300 gross alpha and gross beta results show a similar pattern to those found at the Livermore site. Typical gross alpha activity is 1.4×10^{-5} Bq / m^3 (3.8×10^{-16} Ci / m^3). Typical gross beta activity is 3.6×10^{-4} Bq / m^3 (9.7×10^{-15} Ci / m^3).

The primary sources of observed gross alpha and gross beta activity are naturally occurring radioisotopes of uranium and thorium, their decay products, and any residual fallout from atmospheric weapons testing and the Chernobyl reactor accident in 1986.

Table 5-4 shows the median concentration of $^{239+240}Pu$ on air-filter samples collected from Site 300. (See Data Supplement, Table 5-17 for monthly data.) The highest concentration of ^{239}Pu was observed in the April composite at a level of 1.6×10^{-8} Bq / m^3 (4.3×10^{-19} Ci / m^3), or 0.002% of the DCG.

Table 5-5 shows the median concentration of ^{238}U, ^{235}U, and the $^{235}U / ^{238}U$ ratio on air samples from Site 300. (See Data Supplement, Table 5-18 for monthly data.) The highest concentration of ^{238}U was observed in the March composite at a level of 5.8×10^{-4} µg / m^3 (0.2% of the DCG). The highest concentration of ^{235}U was also observed in the March composite at a level of 1.4×10^{-6} µg / m^3 (0.003% of the DCG). The overall levels were essentially the same as those reported in previous years.

The ratio of ^{235}U to ^{238}U can be used to identify the source of the uranium. Both ^{235}U and ^{238}U occur naturally in the area, but only 0.7% of the naturally occurring uranium is ^{235}U, and the remainder is almost entirely ^{238}U. Because Site 300 operations use depleted uranium that contains very little ^{235}U, it follows that if the ratio remains constant and near 0.7% (within the limit of sampling and analytical error), then the ^{238}U measured is from natural sources. The $^{235}U / ^{238}U$ ratios in March, June, and August are less than expected for natural sources, which indicates some impact from operations at Site 300. The median concentration of ^{238}U for 1998, however, is only 0.01% of the DCG.

Table 5-6 shows the median concentration of tritiated water vapor that was observed at the new sampling location (PRIM) near Site 300. (See Data Supplement, Table 5-19 for biweekly data.) The annual median concentration is 2.4×10^{-3} Bq / m^3 (6.5×10^{-14} Ci / m^3), or 0.0001% of the DCG.

Beryllium in Air

The detection frequency, median concentration, IQR, and maximum concentrations of airborne beryllium for the Site 300 sampling locations are shown in **Table 5-7**. (See Data Supplement, Table 5-20 for monthly data.) The highest beryllium concentration of 37 pg / m^3 occurred in March at location 801E. The median concentration for this location is 0.08% of the federal and state ambient concentration limit, which is 10,000 pg / m^3.

Environmental Impact

The environmental impacts from both radioactive and nonradioactive effluents are described in this section.

Radioactive Materials

LLNL operations involving radioactive materials had little impact on radionuclide concentrations in ambient air during 1998. Radionuclide concentrations in air at the Livermore site and in the Livermore Valley are well below levels that would cause concern to the environment or public health according to existing regulatory standards.

The diffuse tritium sources at B292, B331, B514, and B624 have a localized effect; typically tritium concentrations detected at the site perimeter or off site are not from diffuse sources.

The concentrations of radionuclides measured around Site 300 and in the City of Tracy were well below all standards and, except for uranium isotopes, reflect background or naturally occurring levels of these materials. (See Chapter 13, Radiological Dose Assessment, for a discussion of estimated dose from these data.) The $^{235}U/^{238}U$ ratios in March, June, and August are less than the ratio of naturally occurring concentrations of these isotopes, which suggests the presence of depleted uranium in Site 300 air samples. This depleted uranium can result from current testing of explosives or resuspension of material left over from testing in previous years. Nevertheless, the detected levels remain far below regulatory standards.

Nonradioactive Materials

The concentrations of beryllium at both sites can be attributed to resuspension of surface soil containing naturally occurring beryllium. Local soils contain approximately 1 ppm of beryllium, and the air of the Livermore area and Central Valley typically contains 10 to 100 $\mu g/m^3$ of particulates. Using a value of 50 $\mu g/m^3$ for an average dust load and 1 ppm for beryllium content of dust, a conservative airborne beryllium concentration of 50 pg/m^3 can be predicted. The overall annual medians for the Livermore site and Site 300 are 5.6 pg/m^3 and 6.5 pg/m^3, respectively. These data are lower than predicted, well below standards, and do not indicate the presence of a threat to the environment or public health.